(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 2 548 866 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
23.01.2013 Bulletin 2013/04

(21) Application number: **11756610.9**

(22) Date of filing: **11.03.2011**

(51) Int Cl.:
C07D 209/18 *(2006.01)* ***A61K 31/404*** *(2006.01)*
A61P 19/00 *(2006.01)*

(86) International application number:
PCT/RU2011/000142

(87) International publication number:
WO 2011/115527 (22.09.2011 Gazette 2011/38)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(30) Priority: **15.03.2010 RU 2010109357**

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(54) NEW BIOLOGICALLY ACTIVE COMPOUND N-[3-(4-NITROPHENYLAMINO)-INDOL-2-YLMETHYLENE]AMINOGUANIDINE HYDROCHLORIDE WITH ANTI-INFLAMMATORY ACTIVITY

(57) The present invention relates to the field of chemical-pharmaceutical industry and medicine. N-[3-(4-nitrophenylamino)-indole-2-ylmethylene]amino-guanidine hydrochloride of formula (2) having anti-inflammatory and chondroprotective activity is proposed. The compound does not exhibit adverse effects when used.

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Description

FIELD OF THE INVENTION

[0001] This invention concerns chemical-pharmaceutical industry and relates to a new compound that can be used as an anti-inflammatory drug.

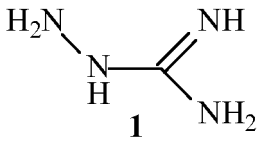
BACKGROUND OF THE INVENTION

[0002] It is known that nonsteroidal anti-inflammatory drugs (NSAIDs) like acetylsalicylic acid (aspirin), indomethacin, voltaren (sodium diclofenac), ibuprofen (brufen) and others are the most widely used drugs for treating inflammatory pathologies [1]. The main adverse effect of NSAIDs is their ulcerogenic action (the ability to damage gastric and duodenal mucous membranes, down to development of ulcerative conditions) due to their effect on biosynthesis of prostaglandins. This complication is associated with inhibition of biosynthesis of prostaglandins, which are physiological (endogenous) gastrocytoprotective substances.

[0003] This makes the research of new compounds, having systemic anti-inflammatory effect but lacking the indicated ulcerogenic effect, quite important.

[0004] From this point of view, a promising venue was the development of a compound having significant anti-inflammatory effect which is not related to the inhibition of prostaglandin synthesis, but acts on the organism via different mechanism of action.

[0005] It is well known that some guanidine derivatives are markedly antagonistic towards nitric oxide (NO) synthases. Especially noteworthy among them are N-aminoguanidine (1) [2], and some of its derivatives.



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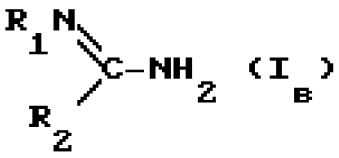
[0006] In most *in vitro* systems aminoguanidine and a known NO-synthase inhibitor L-NMMA (NG-monomethyl-L-arginine) are equally effective in inhibiting of an inducible isoenzyme, but the former is an order of magnitude less active towards constitutive forms, i.e. the former is much more selective [3].

[0007] In animal models aminoguanidine reduces the severity of inflammation diseases, septic shock, increases survival during administration of endotoxins.

[0008] In treating inflammatory diseases aminoguanidine's activity profile is favorable for the patient.

[0009] In terms of a closest analogue salts of amidine derivatives and an inhibitor of cyclooxygenase of a general formula AB can be pointed out, in which A - an inhibitor of cyclooxygenase with carboxylic function; B - a compound of general formula



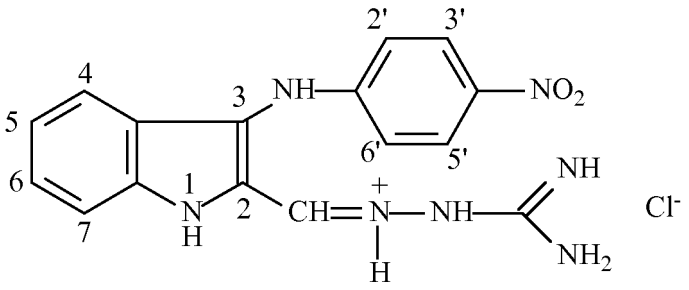
[0010] Compounds according to the invention [8] possess a double biological effect, in which they inhibit NO synthesis and activity of cyclooxygenases and can be used as anti-inflammatory compounds. However, adverse effects characteristic of the aforementioned NSAIDs are inherent to them, although to a lesser degree.

SUMMARY OF THE INVENTION

[0011] The goal of the present invention is the development of a new anti-inflammatory drug that does not exhibit an ulcerogenic effect.

[0012] Accordingly, to achieve this it was deemed optimal to develop a compound that would not only have an aminoguanidine fragment in its structure, but would also have a property to be metabolized in the living organism with releasing aminoguanidine.

[0013] This very property is quite likely for a compound of the present invention - N-[3-(4-nitrophenylamino)-indole-2-ylmethylene]aminoguanidine hydrochloride of a formula (2):



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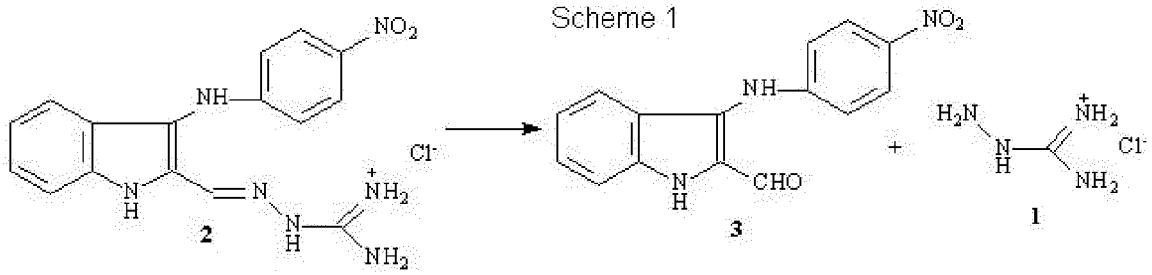
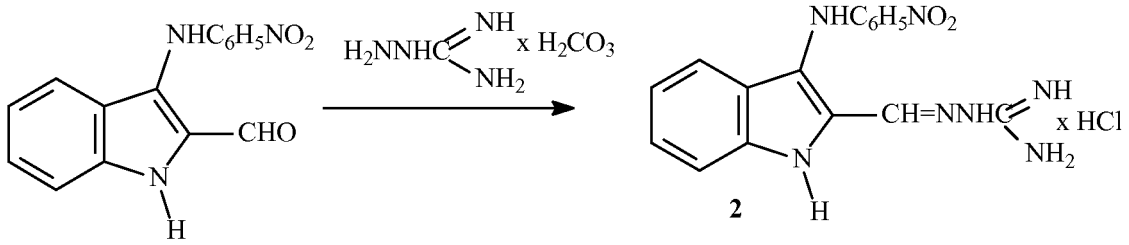
The presence of imine structure gives the compound a property to hydrolyze (like all imines) in aqueous medium according to scheme 1, generating 2-formyl-3-p-nitrophenylindiol (3) and aminoguanidine hydrochloride:

Scheme 1



DETAILED DESCRIPTION OF THE PRESENT INVENTION

[0014] A method of synthesizing of N-[3-(4-nitrophenylamino)-indole-2-ylmethylene]aminoguanidine hydrochloride of formula (2) is based on the interaction of 2-formyl-3-(4-nitrophenyl)aminoindole [9, 10] and aminoguanidine in the presence of hydrochloric acid while heating the mixture in rectified alcohol, ensuring technologically acceptable conditions of synthesizing the target product from readily available raw materials and without the need for special technological conditions.



[0015] The new compound exhibits valuable pharmacological properties: it exerts a systemic anti-inflammatory effect and exhibits chondroprotective properties.

[0016] The possibility of implementation of the present invention can be demonstrated by the following specific examples:

Example 1 Synthesis of N-[3-(4-nitrophenylamino)-indole-2-ylmethylene] aminoguanidine hydrochloride (2)

[0017] A mixture of 1 g (0.356 mmol) of 2-formyl-3-(4-nitrophenyl)aminoindole, 0.58 g (0.43 mmol) of aminoguanidine carbonate, 0.87 ml (0.86 mmol) of concentrated hydrochloric acid, 0.87 ml of water and 26 ml of rectified ethanol is boiled for 1.5 hours. It is then cooled, the precipitate is filtered, rinsed by alcohol and acetone. 1.23 g of hydrochloride is obtained, which is then recrystallized in a mixture of ethanol and water (3:1). Yield 0.8 g (65%). Melting point 310-312°C.

[0018] For large loads the substance was crystallized from aqueous N,N-dimethylfomamide (DMFA).

[0019] The obtained compound has the following NMR-spectrum parameters:

^{1}H NMR (DMS-d_6 , δ): 6,75 and 8,03

7.02, 7.26, 7.44, (all m. 1H, 2H, 1H, 4H, 7H)

7.83 (br.s, 4H, HN-CH=NH_2)

8.18 (s. 1H- α-H)

9.21, 11.69, 11.98 (br.s, 1H, NH(Ph), NH (indole), NH^+)

Example 2 Study of the compound's toxicity properties

[0020] Study of the compound of formula 2 was conducted *in vivo.* The most effective NSAIDs - voltaren and indomethacin were used as drugs of comparison, their main drawback is the aforementioned ulcerogenic action. To determine the doses of the compound that would need to be pharmacologically studied, it is first necessary to study its acute toxicity. Experiments were carried out in male mice with body mass 18-20 g. Compound 2 was administered as a water suspension. Each dose was administered to 5 animals. Behavior and overall condition of animals were observed during 5 days. LD_{50} value characterizing the dose causing the death of 50% of animals was calculated using Karber method.

Table 1.

The effect of the studied compound on mortality of mice.				
Dose, in mg/kg intravenous	Number of animals in the group	Animal mortality		Note
		Alive	Dead	
500.0	5	5	0	Animal behavior without changes
1000.0	5	5	0	Animal behavior without changes
1500.0	5	5	0	Animal behavior without changes
2000.0	5	4	1	Animals depressed

[0021] Considering that only one animal out of five died after intravenous administration of the compound in 2000.0 mg/kg dose, it can be concluded that the studied compound belongs to at least the third class of hazard - moderately hazardous substance, as specified by GOST 12.1.007-76 (classification of harmful industrial substances according to degree of hazard). Further considering that LD_{50} in oral administration may exceed 5000 mg/kg, the compound of formula 2 may be rated as 4 class - low-hazardous substances, i.e. the compound is virtually non-toxic.

Example 3 Study of anti-inflammatory activity

[0022] Activity was studies using the methods listed in "Methodical recommendations on experimental (preclinical) research of new nonsteroidal anti-inflammatory drugs" for new compounds screening, in mouse models of peritonitis induced by lipopolysaccharide (LPS) and carrageenan [4].

1. Carrageenan-induced peritonitis in mice

[0023] Research was carried out by a method described in [5]. Experiments were performed using male mice with body mass 23-24 g, in groups of 10 animals. The studied compounds were administered by a tube into the stomach 1.5 hours before intraperitoneal administration of 0.2 ml 1% λ-carrageenan, after 4 hours the animals were sacrificed and the volume of exudate in peritoneal cavity was measured in ml. The results were processed using variation statistics methods for biological research (calculation of mean and standard error means were compared using Student's t-test criterion).

2. LPS-induced peritonitis in mice

[0024] Anti-exudative action was studied in male mice with body mass of 22.0-23.0 g with peritonitis induced by intraperitoneal administration of lipopolysaccharide (LPS), purified from Escherichia coli (Sigma) 1.0 mg/kg, as described in [6]: after 4 hours the animals were sacrificed (CO_2 inhalation), their peritoneal cavity was opened and the volume of exudate was measured in ml. Studied compounds and drugs of comparison were administered *per* os one hour before LPS, control group was composed of mice receiving 0.3 ml of saline before LPS administration. Each group had 10 animals.

[0025] The results were processed using variation statistics methods for biological research (calculation of mean and standard error, means were compared using Student's t-test criterion).

Results of the study

[0026] Results of experiments and assessment of anti-inflammatory activity of compound **2** are shown in table 2.

Table 2.

Anti-inflammatory activity of compound **2** in mice peritonitis models.				
Studied compounds	Dose, mg/kg (*per os*)	Number of animals in the group	Anti-inflammatory activity in carrageenan-induced peritonitis model, % of control	Anti-inflammatory activity in LPS-induced peritonitis model, % of control
Compound of formula 2	25.0 50.0 100.0 200.0	10 10 10 10	3.9 21.6* 45.1* 84.3*	2.2 46.7* 88.9* 100.0*
Voltaren	25.0 50.0 100.0	10 10 10	80.4* 90.2* 100.0*	82.2* 95.6* 100.0*
Amino-guanidine	50.0 100.0 200.0	10 10 10	25.5* 70.6* 84.3*	51.1* 73.3* 91.1*
*- p< 0,05 compared to control				

LPS-induced peritonitis in rats.

[0027] Anti-exudative action was studied in male rate with body mass 170.0-180.0 g with peritonitis induced by intraperitoneal administration of lipopolysaccharide (LPS), purified from Escherichia coli (Sigma) - 1.0 mg/kg as described in [6]: after 4 hours the animals were sacrificed (CO_2 inhalation), their peritoneal cavity was opened and the volume of exudate was measured in ml. Studied compounds and drugs of comparison were administered *per* os one hour before LPS, control group was composed of rats receiving 0.3 ml of saline before LPS administration. Each group had 7 animals.

[0028] The results were processed using variation statistics methods for biological research (calculation of mean and standard error, means were compared using Student's t-test criterion).

Results of the study

[0029] Assessment of anti-inflammatory activity of compound 2 compared to voltaren and aminoguanidine is shown in table 3.

Table 3.

Anti-inflammatory activity of compound 2 in rat peritonitis model.				
Studied compounds	Dose, mg/kg (*per os*)	Number of animals in the group	Anti-inflammatory activity in LPS-induced peritonitis model, % of control	ED_{50}, mg/kg
Compound of formula 2	10.0 25.0 50.0 75.0 100.0	7 7 7 7 7	2.0 26.0* 58.0* 78.0* 100.0*	48.0 ± 4.5
Voltaren	10.0 25.0 50.0 75.0	7 7 7 7	22.0 65.0* 84.0* 100.0*	20.0 ± 1.5
Amino-guanidine	25.0 50.0 75.0 100.0 200.0	7 7 7 7 7	4.0 22.0* 58.0* 78.0* 100.0*	70.0 ± 2.5
*- p< 0.05 compared to control				

[0030] Anti-inflammatory activity of compound of formula **2** was studied. Results, shown in tables 2 and 3 indicate that the described potential medicament of formula **2** is somewhat inferior to voltaren in used models, but is superior to aminoguanidine.

[0031] Compound **2** exhibits anti-inflammatory action. Most NSAIDs frequently have adverse effects - damage of gastric mucous membranes and ulcerogenic effect.

[0032] Therefore the study of ulcerogenic effect of potential NSAIDs allows on the one hand to detect the presence and severity of ulcerogenic effect and on the other hand to indirectly estimate the effect of the studied compound on prostaglandin biosynthesis.

Methods of the study

[0033] Ulcerogenic effect of compound **2** was studied in accordance with Methodical recommendations on experimental (preclinical) research of new nonsteroidal anti-inflammatory drugs [4]. Studies were performed according to the following scheme:

1. Study of the compounds' irritant action on mice stomach using doses five-times higher than pharmacological dose (single administration).

2. Study of the compounds' ulcerogenic action using pharmaceutical dose during chronic 7 days administration.

3. Aggravation of ulcerogenic effect of studied compounds by 0.6 N hydrochloric acid.

4. Aggravation of ulcerogenic effect of studied compounds by the known NSAIDs (indomethacin).

1. Study of irritant action of compound **2.**

[0034] Male mice with body mass 23-24 g were deprived of food for 24 hours, water access was not limited. Number of animals in a group - 10.

[0035] Compound **2** in 500 mg/kg dose was administered by a tube into the stomach, after 6 hours the animals were sacrificed, their stomachs were extracted, number of ulcers was counted and ulcerogenic index was calculated. Ulcerogenic effect was assessed using 4-point scale: 0 - no damage; 0.5 - hyperemia; 1 - isolated insignificant damage (1 or

2 point bleedings); 2 - multiple damage (erosions, point bleedings); 3 - significant and multiple damage (erosions, bleedings); 4 - severe damage, affecting all gastric mucosa (massive bleedings, erosions, perforations).

2. Study of irritant action of compound **2.**

[0036] Male mice with body mass 23-24 g were administered compound **2** in 200 mg/kg dose *per* os for 7 days. After 7 days the animals were sacrificed by CO_2 inhalation, their stomachs were extracted and the number of ulcers was counted.

[0037] Drugs of comparison *per os*: indomethacin in 20 mg/kg dose, voltaren - 50 mg/kg and aminoguanidine - 200 mg/kg. Each test group had 10 animals.

3. Aggravation of ulcerogenic effect of studied compounds by 0.6 N hydrochloric acid.

[0038] Male mice with body mass 23-24 g were deprived of food for 24 hours, water access was not limited. Compound **2** in 100 mg/kg dose was administered by a tube into the stomach 1 hour before the administration of 0.6 N hydrochloric acid (5 ml/kg), after 4 hours the animals were sacrificed, their stomachs extracted and the number of ulcers counted.

[0039] Drugs of comparison *per os*: indomethacin 20 mg/kg, voltaren - 50 mg/kg and aminoguanidine - 200 mg/kg. Each test group had 10 animals.

4. Aggravation of ulcerogenic effect of compound **2** by the known nonsteroidal anti-inflammatory drugs [1, 4].

[0040] Male mice with body mass 23-24 g were deprived of food for 24 hours, water access was not limited. Compound **2** in 100 mg/kg dose was administered by a tube into the stomach 1 hour before the administration of indomethacin (20 mg/kg), after 5 hours the animals were sacrificed, their stomachs were extracted and the number of ulcers was counted.

[0041] Drugs of comparison *per os*: voltaren - in 50 mg/kg dose and aminoguanidine - in 200 mg/kg dose. Each test group had 10 animals.

Results.

[0042] Results of study of ulcerogenic action of compound **2** compared to voltaren, indomethocine and aminoguanidine are shown in table 4.

Table 4.

Ulcerogenic effect of studied compounds in different conditions.				
Studied compounds	Average ulcerogenic index (4-point scale) of single administration of the compounds in 500.0 mg/kg dose	Average ulcerogenic index (4-point scale) of chronic administration of pharmacological dose	Average ulcerogenic index (4-point scale) of combining the studied compounds with indomethacin	Average ulcerogenic index (4-point scale) of combining the studied compounds with hydrochloric acid
2	0	0	2.2	0.15
Aminoguanidine	-	0	0.19	0.15
Voltaren	-	0.35	2.5	0.55
Indomethacin	-	1.15	-	2.4
Control	-	-	2.0	0.2
*- $p < 0.05$ compared to control				

[0043] As the results show, compound of formula 2 does not exhibit irritant effect on gastric mucosa both in single administration *per* os of 500 mg/kg dose and chronic administration *per* os of 200 mg/kg doses. It also does not aggravate ulceration when combined with 0.6 N hydrochloric acid or indomethacin in 20 mg/kg dose. Drugs of comparison voltaren and indomethacin exhibited ulcerogenic effects, characteristic of NSAIDs.

[0044] Therefore ulcerogenic action of compound **2** was studied, and it was shown that, like aminoguanidine and in contrast to voltaren and indomethacin, compound **2** does not exhibit irritant and ulcerogenic effects in several ulceration

models.

Example 4 Study of chondroprotective properties

[0045] Compound of formula 2 was tested in chronic arthritis (adjuvant arthritis) model in Wistar rats. It was shown that the studied compound has prevented the spreading of inflammation, reducing leukocytosis, tumor necrosis factor-alpha (TNFα) in blood plasma and severity of the development of delayed type hypersensitivity (according to the data of x-ray study of small metacarpophalangeal and distal interphalangeal joints of affected hind leg). The compound in 50 mg/kg dose reduced the level of TNFα similarly to the drug of comparison - indomethacin. Compound **2** in 50 mg/kg dose was most effective in preventing the development of joint sclerosis and narrowing of interphalangeal joints space of hind leg, superseding the effectiveness of the drug of comparison.

[0046] Reduction of cartilage thickness in groups taking various concentrations of the new drug compared to control group was proven; chondroprotective effect of compound **2** was noted in 50 mg/kg dose.

[0047] Based on the aforementioned experimental research a conclusion was made that the new compound possesses systematic anti-inflammatory activity (reduces leukocytosis and pro-inflammatory TNFα cytokine synthesis) in intragastric administration (analog of *per os*). The studied compound in 50 and 75 mg/kg doses reduced the severity of hind leg swelling, in 50 mg/kg dose partially prevented the development of dystrophy of interarticular cartilage of hock. In the same dose the compound has shown a potent (better than indomethacin) chondroprotective action towards interphalangeal joints of affected leg (x-ray data). In intragastric administration (analog of *per os*) the compound has shown systemic anti-inflammatory action (reduction of swelling, leukocytosis, TNFα level, chondroprotective action) that may be associated with the inhibition of delayed type hypersensitivity.

[0048] Assessment of other types of pharmaceutical activity of compound **2** has shown that the compound possesses anti-allergic, antihypoxic and analgesic activity. All identified types of pharmacological activity of compound **2** are present not only in its hydrochloride form, but also in its other pharmaceutically acceptable salts (e.g. Na, K, Ca, Mg), and also in complex compounds with pharmaceutically acceptable complexones (e.g. with glycyrrhizic acid).

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[0049]

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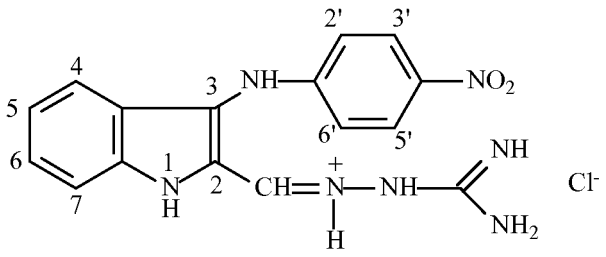
Claims

1. N-[3-(4-nitrophenylamino)-indole-2-ylmethylene]aminoguanidine hydrochloride of formula (2)



2

or its pharmaceutically acceptable salt or complex derivative.

2. N-[3-(4-nitrophenylamino)-indole-2-ylmethylene]aminoguanidine hydrochloride of formula (2) according to claim 1, having systemic anti-inflammatory action.

3. N-[3-(4-nitrophenylamino)-indole-2-ylmethylene]aminoguanidine hydrochloride of formula (2) according to claim 1, having chondroprotective action.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/RU 2011/000142

A. CLASSIFICATION OF SUBJECT MATTER

C07D 209/18 (2006.01); A61K 31/404 (2006.01); A61P 19/00 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C07C 209/18, A61K 31/404, A61P 19/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

STN International Database, CHEMCATS, PatSearch

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	RU 2167856 C2 (SOSIETE DE KONSEI DE RESHERSH E D'APPLIKACION SIENTIFIK (S.K.R.A.S.) 27.05.2001	1-3
A	RU 2095347 C1 (ANDOS AG) 10.11.1997	1-3
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☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
15 July 2011 (15.07.2011)	11 August 2011 (11.08.2011)
Name and mailing address of the ISA/ RU Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 1998)

REFERENCES CITED IN THE DESCRIPTION

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